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ABSTRACT

The relationship of concrete operations to beginning reading was investigated with three samples of early readers and prereaders: prekindergarten and kindergarten children who were early readers and those who were not yet reading. Piagetian tasks on conservation of number, conservation of quantity, seriation, multiple classification, and class inclusion were administered. There were no significant differences between the performances of early readers and prereaders on these concrete operational tasks. The data support the conclusion that concrete operations are neither necessary nor sufficient for beginning reading. Directions for future research are suggested. (Author/RH)

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The Performance of Early Readers and Prereaders on Concrete Operational Tasks: Three Samples

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Abstract

The relationship of concrete operations to beginning reading was investigated with three samples of early readers and pre-readers (prekindergarten and kindergarten children who were reading early and those who were not yet reading). The following Piagetian tasks were administered: conservation of number, conservation of quantity (mass), seriation, multiple classification, and class inclusion. No significant differences were found between the performances of early readers and pre-readers on these concrete operational tasks. The data support the conclusion that concrete operations are neither necessary nor sufficient for beginning reading. Directions for future research are suggested.

The Performance of Early Readers and Prereaders on Concrete Operational Tasks: Three Samples

The relation of concrete operational thought to learning to read remains an issue, unsettled by theoretical controversy and equivocal research findings. Elkind (1970, 1974, 1975, 1981) has maintained that children need to have attained concrete operations, specifically conservation, classification and seriation, in order to begin reading successfully. According to Elkind (1981), the left to right scanning in reading requires seriation, and the decoding of graphemes that represent more than one sound, e.g., the letter *a* representing short *a* and long *a*, requires logical addition. Formerly Elkind (1970) considered the latter to be a case of logical multiplication, but in the latest publication the diphthong *ow* is cited as an example of logical multiplication, wherein the child having separately learned the sounds of *o* and *w* now must put them together to form the diphthong *ow*. Elkind (1981) suggested stages in the development of reading, identity decoding and equivalence decoding, that parallel his distinction of identity and equivalence conservation.

Murray (1978a) seemed to concur with several of Elkind's interpretations, e.g., left to right processing of print as requiring seriation, decoding vowel grapheme-phoneme correspondences as requiring multiple classification, and recognizing the different forms of a word as requiring decentration. However, Murray (1977,1978a, 1978b), noting that preoperational children do learn to read, concluded that concrete operations are a sufficient condition rather than a necessary condition for beginning reading.

Taking issue with Elkind's differentiation of conservation and with his application of Piaget's theory to beginning reading, Zimilies(1981) considered Elkind's application to be an overextension of Piagetian constructs. Zimilies argued, for example, that a single letter

representing several sounds is a type of *function* rather than a case of multiple attributes and multiple classification.

Ginsburg and Opper (1979, p. 232), noting that it was not clear how concrete operations relate to reading, concluded that Piaget's theory had "little if anything to say about reading...", and later Ginsburg (1981) cautioned that designing models of either reading decoding or comprehension based on Piagetian constructs would not be productive.

In examining the applications of Piaget's theory in the research on reading, including those of Elkind and Murray, Gallagher (1979) questioned the validity of such application. Noting that in Piaget's (1977) recent model of equilibration, conservation is described as a gradual process of attainment, Gallagher questioned the premise that children need to be able to conserve before they can learn to read, for learning to read also is a gradual process. Drawing a parallel between the psycholinguistic model of the reading process, wherein coordination of factors is central, and Piaget's equilibration model of cognitive development, wherein coordination also is central, Gallagher pointed to new directions for research, namely investigating the coordination process itself and examining this and other reconstructing processes in relation to reading comprehension. Gallagher noted that psycholinguistic theories that view reading as a process of constructing meaning from the text were in keeping with Piaget's constructivist theory. Donald (1981) and Roberts (1984) came to the same conclusion.

Most of the research investigating Piaget's theory and its application to reading consists of correlational studies, in which, as Waller (1977) noted, the highest correlation occurred with seriation and the lowest with classification and conservation. Comprehensive reviews of the research have been reported by Waller (1977) and by Murray (1978b). The results of this research were inconclusive, a fact which led Waller to

conclude that concrete operations may be a sufficient but not a necessary condition for learning to read.

Research since the Waller and Murrary reviews continues to provide inconsistant results. Three studies published late in 1976 revealed inconsistant results concerning conservation and reading. Cox (1976),testing children 7-12 years of age, found that children reading at or above grade level performed significantly better on conservation tasks than did children reading below grade level. Mean scores on the conservation tasks increased with age for both groups. The two groups achieved success on all conservation tasks at the same ages, 11 and 12 years. Opert, Meyers, and Griffin (1976) found a correlation of .13 between second graders performance on the liquid conservation task and on subtests of the Stanford Achievement Test. No difference in reading performance was found between groups reflecting different stages of conservation. Similar results were revealed in the research of Hagan (1976), who, after part correlation was used to determine differences between first graders' performance on conservation tasks and on the Metropolitan Primer and Primary tests, found the originial correlations of .57 and .40 reduced to .095. Thus Hagan concluded that conservation was not a good predictor of first grade reading achievement.

No single Piagetian task, according to Arlin (1981), is a valid predictor of achievement in reading (or in mathematics). Instead Arlin argued for using a wide range of tasks that represent the subsystems of seriation, classification and conservation, which would yield a better measure of operativity than any single task. As with other studies, her research revealed low positive correlations between the individual Piagetian tasks and reading achievement. In the regression analysis, however, the double seriation task proved to be the most predictive of achievement in reading. Arlin pointed out that this task required transitivity, one-to-one correspondence, and coordination.

In contrast, Miller-Jones (1981) suggested that ordering rather than seriation was more closely related to reading, a point born out by her research in which ordering was the strongest predictor of fall to spring reading for 5-7 year olds and seriation the weakest predictor. An analysis of scores of a group within the sample identified as fast learners (non-readers who learned to read) revealed that they excelled in the logical task of multiple classification, along with language and perceptual tasks (C.Miller-Jones, personal communication, August 2, 1982).

Katz and Carlson (1977) reported low to moderate correlations between scores of first grade children on seriation tasks and on subtests of the Comprehensive Test of Basic Skills; however two seriation tasks that yielded the highest correlations did not include the operational step of inserting additional units into the completed series.

Studies of early readers' performance on Piagetian tasks have also produced equivocal results. Ellis (1978) tested gifted preschool readers on tests of conservation and classification. Only the latter seems to have yielded a positive correlation, but these tasks do not appear to be operational. That is, in one item the classification required subjects to group on the basis of similarity, which is a preoperational achievement (Stage 2 of classification); in the other item the subclass referred to in the class inclusion question is smaller than the complementary class, thus children could give the correct answer by comparing the subclasses rather than by comparing the subclass and the whole class. Although no control group was studied, the sample was divided so as to compare levels of early reading. Advanced early readers performed significantly better on conservation tasks than did the grade level readers.

Three studies have compared the performance of early readers and non-early readers on concrete operational tasks, but the results do not present clear-cut evidence. Briggs and Elkind (1973) reported a factor analysis of scores in which the operativity factor yielded a

significant *F* between early readers and non-early readers; however, the operativity factor was derived from the Goldschmidt-Bentler Conservation Battery in combination with a different kind of measurement, the Matching Familiar Figures Test. In a later extension of this study, the operativity factor did not emerge, but Briggs and Elkind (1977) reported that early readers scored higher than non-early readers on the Conservation Battery ($p < .07$). However, the testing condition may have reduced the difference, for the non-early readers were tested on Piagetian tasks six months later than the early readers. A study by Polk and Goldstein (1979) of early readers and non-early readers at the beginning of first grade also reported significant differences between the two groups on conservation tasks; here, though, the scoring of the tasks included items that are within the cognitive grasp of preoperational children, for example, one-to-one correspondence. Thus the results of these three studies provide evidence that remains equivocal.

To contribute to clarification of this issue, the present report provides data from three samples of early readers and prereaders, the term used here for children who were not yet reading. Reading scores were the basis for group assignment, and scores on concrete operational tasks were the bases for comparison. The data were gathered over the past decade: the first sample was tested in June and July of 1976; the second sample was tested in June and July of 1977, and the third sample was tested in March of 1984. The samples were from different communities. The subjects and procedures are described below for each sample, and the results are also reported separately. The discussion of results includes the three samples.

Sample 1

Method

Subjects.--The subjects were 36 children enrolled in five kindergarten classes serving middle to upper middle class neighborhoods in a surburban city. Kindergarten teachers were asked by the district office to identify children in their classes who were reading. This writer than administered the Wide Range Achievment Test (WRAT) to those 23 children. Children scoring at Grade 2.0 and above, l8 subjects with a range from 2.0 to 5.l on the WRAT, were selected as early readers (ER) and matched on age, sex, and social class with children identified as prereaders. The prereaders (PR) scored at or below grade 1.2 on the WRAT, with a range from K.l to l.2. The difference on the WRAT between the two groups was significant at the .0l level (t = l2.07).

The mean age for the ER subjects was 62.83 months; for the PR subjects the mean was 62.72 months.

Procedures.-- The following Piagetian tasks were administered in the order given. l. Two conservation of number tasks, the first a provoked correspondence task (Piaget, 1965) using 8 vases and 8 plastic flowers, and the second an unprovoked correspondence task using 6 red and 6 black checkers. After the child established the one-to-one correspondence, the transformation was performed, i.e. one row was extended, and the child was asked the conservation question: Now are there the same number of flowers (or checkers)? The checkers task included another conservation question asked in relation to the extended row when returned to the original position. Each correct response to the conservation question was scored as 1 point; each correct justification, based on identity, inverse or compensation reasons (Piaget,1976), was scored as l point. A total of 6 points was possible for this item.

2. Two conservation of quantity (mass) tasks, using two clay balls. In the first task one ball was elongated, and in the second task one ball was flattened. After the transformations the child was asked the conservation question. The same scoring as in Item l was used, and

a total of 4 points was possible for this item.

3. Two seriation tasks. After constructing a graduated series of 9 rods or slats, the child was asked to place 5 insert items, one at a time, where they belonged in the series. Following Elkind (1964), 8 points were possible for this item.

4. Two class inclusion tasks: 4 carrots + 2 pieces of corn = food, with the class inclusion question: Are there more carrots or more food?; 8 blocks + 3 cars = things to play with, followed by the question, Are there more blocks or more things to play with?

Scoring: 1 point for each correct response and 1 point for each explanation, for a possible total of 4 points.

5. Two multiplication of classes tasks (Inhelder and Piaget, 1964), one a cross classification task (drawings of white and black seated and jumping rabbits),the other a matrix task . In the cross classification task, after the introductory direction to put together the ones that were alike, the subject was given the following directions to execute (points for correct responses in parenthesis):

5.1 Now divide all the pictures into four piles in this box. (l)

5.2 Now make two piles that are the same in some way. (1) Reason (1)

5.3 Now can you put them together in two piles in a different way? (1) Reason (l)

5.4 Now make four piles again, but when this strip (vertical) is taken away thesetwo piles will go together and when this strip (horizontal) is taken away these two piles will go together in some way. (l) Reason (1)

A total of 7 points were possible for the cross classification task.

The following questions were asked for the matrix task, each scored as 1 point for a correct response: Which of these pictures would go here? Why? Is there anything that would fit in better? Why? (or Why not?)

Tasks were administered to subjects individually in an isolated area of the classroom or in a nearby room familiar to the children.

Results

For items 1-4, the scores of the two tasks were combined, and the t-test for matched samples was performed. For item 5, multiplication of classes, scores of the two tasks were not combined; the t-test for matched samples was performed for the cross-classification task and for the matrix task.

The results for all tasks are presented in Table 1.

Table 1

Comparison of Early Readers (ER) and Prereaders (PR) on Concrete Operational Tasks: Sample 1

	ER (N=18)		PR (N=18)			
	M	SD	M	SD	t^a	p
Conservation of Number	4.39	2.50	4.72	2.16	0.4123	n.s.
Conservation of Quantity	1.22	1.83	1.44	1.91	0.3344	n.s.
Seriation	5.83	2.07	5.67	2.43	0.2592	n.s.
Class Inclusion	0.78	0.14	0.50	0.12	0.5663	n.s.
Cross Classification	2.56	1.54	2.78	1.31	0.5920	n.s.
Matrix	0.94	0.15	1.72	0.14	1.4924	n.s.

[a] t-test for matched samples (df=17)

As indicated in Table 1, no significant differences were found in Sample 1 between the performance of early readers and prereaders on the tested concrete operational tasks.

Sample 2

Method

Subjects.--The present investigator administered the WRAT to the total enrollment (101 children) of prekindergarten classes serving children in a suburban city comprised of middle class and working class neighborhoods. To obtain a sample of early readers, it was necessary to use the range 1.3 to 4.5 on the WRAT; 11 early readers were selected. The range for the matched prereaders was K3 to 1.2, with the highest prereaders matched with the highest early readers. The difference on the WRAT betwen the two groups was significant at the .01 level (t=4.74). The subjects were matched on age (mean score for each group was 63.0 months), sex, and social class.

Procedures.-- Same as for Sample 1.

Results

As notead in Table 2, no significant differences were found in Sample 2 between the early readers and prereaders on any of the tested concrete operational tasks.

Table 2

Comparison of Early Readers (ER) and Prereaders (PR) on Concrete Operational Tasks: Sample 2

	ER (N=11)		PR (N=11)			
	M	SD	M	SD	t^a	*p*
Conservation of Number	3.18	2.64	2.55	2.34	0.4762	n.s.
Conservation of Quantity	0.91	1.58	0.00	0.00	1.9122	n.s.
Seriation	5.82	1.94	5.00	2.57	1.3299	n.s.
Class Inclusion	0.36	0.92	1.00	1.41	2.0553	n.s.
Cross Classification	2.18	1.47	2.18	1.79	0.0000	n.s.
Matrix	0.36	0.67	0.45	0.69	0.5590	n.s.

[a] t-test for matched samples (df=10)

Only three early readers in Sample 2 tested on the WRAT in the range of the early readers in Sample l, a difference that may be attributed to the social class difference existing between the two suburban cities.

Sample 3

Method

Subjects.--Thirty-two subjects from three kindergarten classes in an upper middle class community were originally randomly selected for another study that included conservation of number tasks; upon completion of the testing for this study, other concrete operational tasks were administered on another day. The school district previously had administered the Stanford Early School Achievement Test (SESAT), and when the reading scores became available, high and low scoring children were selected as early readers and prereaders. The range of SESAT grade equivalent ratings for the 13 early readers (6 boys, 7 girls) was l.7 to 2.2; the range for the 13 prereaders (5 boys, 8 girls) was K.l to l.2; 6 children, 3 boys and 3 girls scoring l.4 and l.5, were omitted from the study. The mean age of early readers was 68.46 months; the mean age of the prereaders was 68.00 months.

The children had been given the following phonics tests for another study: Letter Recognition from the Metropolitan Readines Tests (MRT) Level l , Form P; Beginning Consonants, (MRT) Level 11, Form P; Sound-Letter Correspondence, (MRT) Level 11, Form P; and two substitution of intitial consonant tests, one adapted from Haddock (1976), the other a type of phonics exercise used in primary classrooms (fab, nab, mab, pab, rab, sab, wab). The range of total phonics scores for the early readers was 44 to 51; the range for pre-readers was 17 to 47. The difference between means of the two groups was significant at the .00l level.

Procedures.--The tasks were the same multiplication of classes tasks, the same seriation tasks, and the same conservation of number task with unprovoked

correspondence as in Samples 1 and 2; a second conservation of number task with unprovoked correspondence was included. The class inclusion tasks and the conservation of quantitiy tasks were not administered.

Results

The t-test for independent samples was computed to determine if differences in performance on concrete operational tasks existed in this sample of early readers and prereaders. The results are presented in Table 3.

Table 3

Comparison of Early Readers (ER) and Prereaders (PR) on Concrete Operational Tasks: Sample 3

	ER (N=13)		*PR (N=13)*			
	M	SD	M	SD	t^a	*p*
Conservation of Number	3.31	1.25	2.46	2.03	1.282	n.s.
Seriation	7.46	0.88	7.54	0.88	0.224	n.s.
Cross Classification	3.62	1.61	3.77	1.83	0.227	n.s.
Matrix	0.69	0.95	0.54	0.78	0.453	n.s.

[a] t-test for independent samples (df=24)

Again, in Sample 3, as indicated in Table 3, no significant differences were found between early readers and prereaders in their performance on the concrete operational tasks of conservation of number, seriation, and multiple classification.

Test of Operativity

Scores of the cross classification and matrix tasks were combined so as to approximate a measure of operativity beyond the single tasks, albeit perhaps not a measure derived from the wide range of subsystem tasks recommended by Arlin (1981). Yet the two types are prototypes of the subsystem multiple classification (Inhelder and Piaget, 1964). Further, the cross classification task includes steps (5.1, 5.2 and 5.3) that require

the child to classify on the basis of alternate criteria; thus, the entire task includes a broader measure than the cross classification step. For Samples 1 and 2, the t-test for matched samples was used, and the t-test for independent samples was used for Sample 3. The results for each sample are presented below in Table 4. No significant difference was found between early readers and prereaders on this measure of operativity.

Table 4

Comparison of Early Readers (ER) and Prereaders (PR) on Combined Multiplication of Classes Tasks

			ER		PR				
	df	N	M	SD	N	M	SD	*t*	*p*
Sample 1[a]	17	18	3.50	2.50	18	4.50	1.92	1.52	n.s.
Sample 2[a]	10	11	2.55	2.64	11	2.64	1.75	0.11	n.s.
Sample 3[b]	24	13	4.31	3.31	13	4.31	0.00	n.s.	n.s.

[a] t-test for matched samples
[b] t-test for independent samples

Discussion

The data from three samples of early readers and prereaders revealed no significant differences between their performance on the concrete operational tasks of conservation of number, seriation, and multiplication of classes, both cross classification and matrix classification. The data from two samples revealed no significance difference on the conservation of quantity tasks and on the class inclusion tasks. Prereaders did as well on these concrete operational tasks as did early readers. Across the sample, in no task did

either group, early readers or prereaders consistently score higher than the other, nor did any child score concrete operational on all tasks.

The matrix classification appeared to be the most difficult for both early readers and prereaders in the three samples. Analysis of the degree of difficulty of the tasks is complicated by the fact that the scoring for the cross classification and seriation tasks included scored steps (subtasks) that are within the cognitive level of preoperational children. For example, in the seriation task, credit was given for the construction of the asymmetrical series by trial and error, which is a Stage 2 achievement ; whereas in the conservation of number task credit was not given for constructing the initial correspondence, also a Stage 2 achievement. Therefore, statistical analysis was not conducted to determine the level of difficulty of the tasks.

The combined tasks of multiple classification as a test of operativity did not yield significant results. This finding does not support Arlin's suggestion that operativity rather than single tasks would yield a relation to beginning reading; however, the range of tasks for this subsytem of operativity may not have been a wide enough measure.

The data presented here, then, do not support the hypothesis that children need to be concrete operational before learning to read. The fact that early readers and prereaders were both successful and unsuccessful on the tasks leads to the conclusion that concrete operations are neither necessary nor sufficient for beginning reading.

These conclusions pertain only to beginning reading and instruction and testing regarding decoding. Where reading passages contain material related to concrete operations and children are asked to interpret the material logically, as Hawk and Asbill (1978) found with certain comprehension items in the Reading Test of the California Assessment Program, children need to possess the particular concrete operation(s). For example, an item cited in Hawk and Asbill requires, among other operations,

asymmetrical ordering as in the Piagetian seriation task. The item included information about whales of different sizes, one referred to as a baby whale. Preoperational children gave a response that appears to be a case of assimilation to the conceptual scheme of babies being small.

The role of assimilation in reading comprehension has not been an area of investigation in the application of Piaget's theory to reading. Nor has Piaget's theory been drawn upon in the development of schema theory, which elaborates conditions and processes concerning reading comprehension (Anderson and Pearson, 1984) . Gallagher (1981) called for the application of Piaget's theory to the development of reading comprehension, focusing not on Piagetian tasks but, rather, on theoretical constructs that have implications for teaching, for example,the difference between empirical and reflexive abstraction and their affects on reading comprehension. Assimilation is another such construct that is especially applicable to the development of reading comprehension.

The comprehension task cited above required concrete operations, including asymmetrical ordering. The ordering required for decoding, though, does not seem to this writer to require asymmetrical ordering but, rather, an ordering more like Piaget and Inhelder's (1967) task in which preoperational children duplicated a model of beads strung in a row. The Stage 2 child is capable of forming ordered correspondences and of transposing a circular order of beads into a linear order. In some beginning reading and writing tasks, children build words using alphabet blocks following a model and copy words letter by letter from a model. Miller-Jones (personal communication, August 2, 1982) found that, of the tasks she tested, which included order, orientation, multiplication of classes and seriation, the ordering task best predicted fall to spring reading achievement of 5 to 7 year old children.

To determine what aspects of cognition are involved in beginning reading, we need to examine what is required in decoding and how that relates to what is developing cognitively in preoperational children. Central to the decoding process is the formation of correspondences. Much of phonics instruction is devoted to helping children form phoneme-grapheme correspondences: one-to-one sound symbol correspondences, as with b, d, t, and most consonants, and one-to-several correspondences, as with c, g, s, and the vowels. The symbol *b* represents one sound; the symbol *a* represents several sounds. Which sound a vowel represents depends upon the context in which it appears. For example, in the consonant-vowel-consonant (CVC) context the vowel is short, whereas in the CVC-silent e context the vowel is long. Thus, the sound a vowel represents is a function of the context in which the vowel appears--a functional relation exists between the vowel (also c, g, and s) and the context in which it appears.

Piaget's work in the development of correspondences (Piaget, 1979) may contribute to an understanding of this process. What Piaget characterized as the preoperational child's *logic of functions* (Piaget & Inhelder,1969) may be the cognitive factor in beginning reading, rather than concrete operations. The preoperational child's logic of functions may provide a fruitful direction for research on the application of Piaget's theory to beginning reading.

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